# Effect of water extracts of larch on growth of Manchurian walnut seedlings

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**Abstract**: A study was conducted to detect the effect of water extracts from different parts such as root, bark, branch and leaf, of adult larch, *Larix gmelini*, trees on growth of Manchurian walnut, *Juglans mandshurica*, seedlings and the allelopathy between the two tree species. Four concentrations (100 $g \cdot kg^{-1}$, 50 $g \cdot kg^{-1}$, 25 $g \cdot kg^{-1}$ and 12.5 $g \cdot kg^{-1}$) were prepared for each kind of extracts. Result showed that the water extracts with low and moderate concentrations accelerated the growth of collar diameter and increased biomass and root/shoot ratio of walnut seedlings. The water extracts from branches and barks with low and moderate concentrations accelerated the height growth of the seedlings, while those from leaves and roots slightly decreased the height growth of seedlings. The fact that application of water extracts of larch improved the growth of Manchurian walnut attributes possibly to the allelopathy between the two tree species.

**Keywords**: *Juglans mandshurica*; *Larix gmelini*; Water extract; Collar diameter; Tree height; Root/shoot ratio; Allelopathy
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## Introduction

Manchurian walnut (*Juglans mandshurica*) is one of the rare tree species in Northeast China and has compact timber quality and straight texture. However, the establishment and management of pure Manchurian walnut plantation are relatively difficult due to its ecological and biological characteristics. Silvicultural practice showed that larch (*Larix gmelini*) could evidently accelerate the growth of Manchurian walnut in mixed plantations of the two species. The dominant height, diameter at breast height, individual volume, and the stand stocking per hectare in mixed plantations of Manchurian walnut and larch were 1.33, 1.87, 4.71, and 1.69 times as many as those in pure walnut plantation, respectively (Shi 1991; Han 2002). The further studies showed that vertical distribution of the root system is a layer-distribution mode in mixture of Manchurian walnut and larch. The fine roots of walnut distributes mainly in soil horizon of 0–20 cm, while that of larch distributes in soil horizon of 20–40 cm, which is a favorable distribution for avoiding competition of tree for soil water and nutrients (Shi 1991). Meanwhile, some of the studies suggested that available P in the rhizosphere was much higher in the mixture of walnut and larch than in pure walnut plantation (Chen 2002). And it is believed that Manchurian walnut trees can more reasonably and effectively utilize soil water and nutrients in mixed plantations than in pure ones, which is a main reason for better growth of Manchurian walnut. However, up to date, no study has investigated the allelopathy between the two tree species.

In recent years, many studies have been conducted on allelochemical interaction between trees species in forest ecosystem, influence of allelochemicals on community succession, and even on ecosystem and development of plant allelopathy (Zhai 1992; Zhai 1993; Wardle 1998; Romeo 2000; Malik 2000). Allelochemicals can be released from died remants to environment. Thus, whether there is allelopathy between Manchurian walnut and larch in a mixture of the two species become an interesting topic. In this study, water extracts from different organs of adult larch trees, such as root, bark, branch and leaf, with different concentrations, are used to test their effects on growth of Manchurian walnut seedlings and the allelopathy between the two species.

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## Material and method

### Preparation of water extract and cultural medium

Ten larch trees were randomly sampled in mature larch plantations (planted in 1960) in the Urban Forestry Demonstration Base of Northeast Forestry University, Harbin (200 m above MSL, 126°37′E, 45°41′N), China. The climate here is semi-arid, with an annual rainfall of 600 mm, annual accumulated temperature of 2 556 °C. Soil type is black soil. The woodened side roots were carefully dug up, meanwhile, fresh leaves, barks and branches were collected from the sample trees for preparing water extracts. For each organ of trees, 5 kg of air-dried material was weighed and shaken in 50-kg distilled water for 24 h, then, the extracts were filtered by gauze. Four concentrations (100 $g \cdot kg^{-1}$, 50 $g \cdot kg^{-1}$, 25 $g \cdot kg^{-1}$ and 12.5 $g \cdot kg^{-1}$) were prepared for each kind of extracts. All extracts were stored at 0℃ in a refrigerator prior to use. The uniform one-year-old Manchurian walnut seedlings from Baolongdian Seeds Forest Farm of Wuchang County in Heilongjiang Province were chosen to be applied with the water extracts. The cultural medium was water-washed and sterilized sand.

### Experimental design

A complete randomized block design was used with 16 testing blocks, one control block in the experiment, and eight replications in every block. On April 29th, 2004, the one-year-old *J. mandshurica* seedlings were transplanted into 40 cm × 50 cm pots (one seedling per pot) with 35-kg sterilized sand and put in a greenhouse. A week after transplanting, the extracts with different concentrations and Hoagland nutrient solution were separately applied to each testing pot (50 mL per pot) every week, while only Hoagland nutrient solution was applied to the control pots in 50 mL per pot. Meanwhile, a same quantity of water was

poured into every pot according to the requirement of experimental design.

### Measurements of growth indexes

On August 25th, 2004, after measuring the height and collar diameter, the experimental seedlings were pulled out from the pots and washed with water. The above parts and underground parts of seedlings were separated and put in an oven to dry at 80℃, after then, biomass and root/shoot ratio were determined.

## Results and analysis

### Effect of leaf water extract on growth of walnut seedlings

The experimental results showed that the leaf water extracts of four designed concentrations accelerated the growth of collar diameter and increased biomass of walnut seedlings. The collar diameter of seedlings in test blocks treated by 25 $g \cdot kg^{-1}$ leaf water extracts was significantly different from that in control ($P < 0.05$). However, there was no significant difference in collar diameter and biomass of seedlings between the test blocks treated with the four concentrations of leaf water extracts. With the concentration increasing, the growth of walnut seedlings had a decreasing trend, and till stabilization (Fig. 1). Collar diameter growth was promoted by the extract of any concentration, while biomass was mainly enhanced by low concentration of leaf water extracts. Height growth and root/shoot ratio of walnut seedlings were reduced slightly by any concentrations, but the differences were not significant between testing and control blocks.

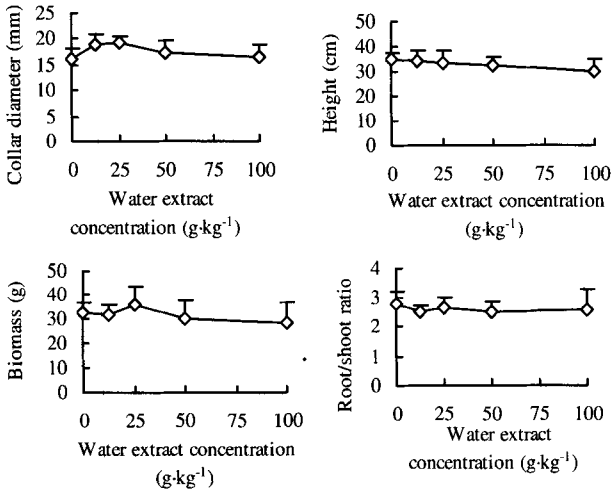


**Fig.1 The effect of leaf water extract on the growth of one-year-old walnut seedlings**

### Effect of root water extract on growth of walnut seedlings

With concentration increasing of root water extract, the growth of collar diameter had a slightly increase, reversely, the growth of tree height was slightly reduced. However, the differences in collar diameter and tree height growths were not significant between the testing and control blocks (Fig. 2). The root/shoot ratio and biomass of walnut seedlings had large promotions at 12.5 $g \cdot kg^{-1}$ root water extract, and then, these indexes started to decline with the concentration increasing. It is obvious that the root/shoot ratio and biomass of the seedlings were promoted by the low concentration of root water extracts.

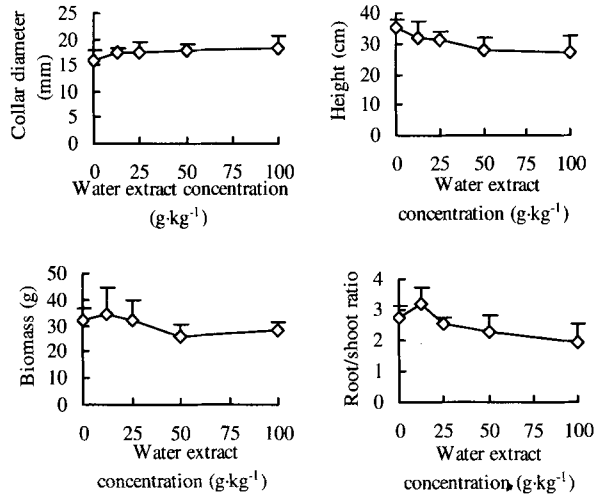


**Fig.2 The effect of root water extract on the growth of one-year-old walnut seedling**

### Effect of bark water extract on growth of walnut seedlings

Growth of collar diameter of walnut seedlings had a great increase at 50 $g \cdot kg^{-1}$ bark water extract and the difference between the testing and control blocks was significant ($P < 0.05$). The biomass of the seedlings was increased largely at 25 $g \cdot kg^{-1}$ bark water extract. However, the differences in collar diameter and biomass were not significant between the blocks treated with any concentration. Moreover, biomass and growth of tree height exhibited a deceasing trend and the root/shoot ratio had an ascendant trend with the increase of concentration (Fig. 3). Thus, the growth of collar diameter and biomass were apt to be improved in low and moderate concentrations of bark water extract. The differences in tree height and root/shoot ratio were not significant between the all blocks treated with any concentration extracts and the control.

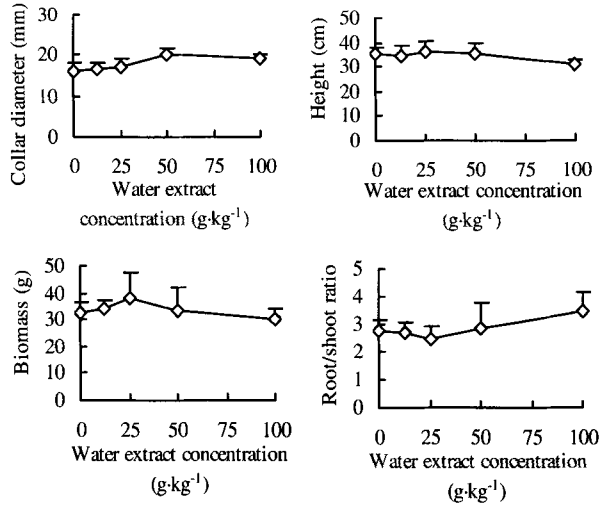


**Fig.3 The effect of bark water extract on the growth of one-year-old walnut seedlings**

### Effect of branch water extract on growth of walnut seedlings

The branch water extract of all concentrations had hardly any effect on the growth of collar diameter (Fig. 4), but the low con-

centration (12.5 $g \cdot kg^{-1}$) of branch water extract had greatly promoting effects on height growth, biomass and root/shoot ratio of the seedlings.

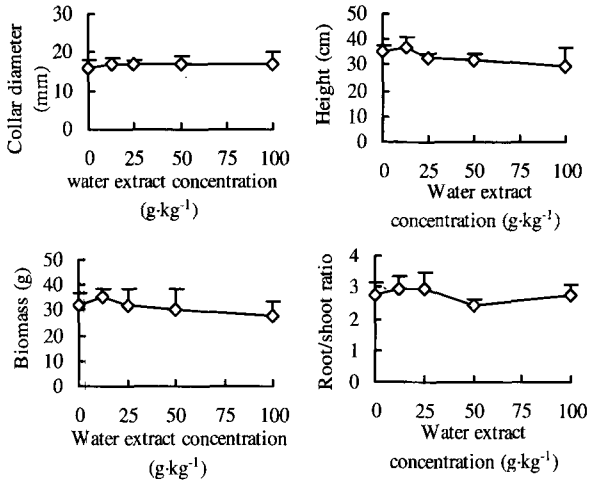


**Fig. 4 The effect of branch water extract on the growth of one-year-old walnut seedlings**

## Discussion

Silvicultural practice showed that the mixture of Manchurian walnut and larch is remarkably favorable for increasing growth of walnut trees. And the same thing happened to ash (*Flaxinus mandshurica*) in a mixed plantations of ash and Larch (*L. gmelini*) (Liu 1991; Hu 1991). The mixed plantation greatly improved physical characteristics of soil, and available nutrients in the top soil were higher in mixed plantations than in pure ones (Wang 1994) and also improved intake of P and K by ash (Zhang 2002). The mixture changed spatial distribution and configuration of root systems of ash and larch, and fibres of ash centralized mostly on soil superstratum (0–20 cm), while fibres of larch mostly in soil underlayer (20–60 cm). The distribution made ash absorb more nutrients and water and improve its competition efficiency (Wang 2000; Zhang 2001; Wang 2002). The two species all had N absorbing which was stagger. For ash, N fastigium appeared in the end of June, while for larch in the end of July (Cui 2001).

The current study suggested that there are only two viewpoints on the reason why larch accelerates growth of Manchurian walnut or ash when they grow together. One is that their root systems are a layer distribution in mixed plantations of larch and Manchurian walnut (or ash) which is advantage to avoiding water and nutrient competition, and the other is that soil nutrient conditions were improved due to their voluminous root systems. However, the fact is not always the same. According to the soil nutrient analysis of pure and mixed plantations of larch and Manchurian walnut (planted in 1969, 127°42′E, 45°17′N, adjoining our experimental site) in Xiaojiu Forest Farm of Shangzhi Forestry Bureau, Heilongjiang Province, the soil total N, total P, total K and organic matter in A-layer, from high to low was: mixture of larch and Manchurian walnut, pure walnut plantation, pure larch plantation (Chen 1991). However, other soil nutrient analysis of three plantations (127°35′E, 43°25′N, planted in 1969) in Erlangshan Range of Bihe Forest Farm, Baishishan Forestry Bureau of Jilin Province indicated that the soil total N, P, K and organic matter in soil were: pure walnut plantation > mixture of Larch and walnut > pure larch plantation (Shi 1991).

In the middle of the 1980s, Rice (1984) particularized many facts to explain that allelopathic competition was the reason of interaction among trees and other plants. Other researchers also reported that the allelopathy was of importance in forest ecosystem and its management (Jobidon 1992). Wu (2000) also demonstrated that litters from larch could accelerate growth of ash in allelopathy research.

Our experimental results suggested that water extracts of low and moderate concentrations of larch could accelerate growth of Manchurian walnut seedlings in collar diameter and increase its biomass and root/shoot ratio. The branch and bark water extracts of larch with low and moderate concentrations could accelerate height growth of walnut seedlings, while the leaf and root water extracts of *L. gmelini* could slightly decrease height growth of the seedlings. The fact that water extracts of larch accelerate the growth of walnut seedlings possibly relate to the allelopathy between the two tree species. In future research, much more attention should be paid to the separation, identification and function mechanism of allelochemichals.

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